A New Approach for Measuring *in situ* the Concentration and Settling Velocity of Suspended Cohesive Sediment

Thesis submitted by

Alessandra Mantovanelli (MSc) UFPR-Brazil

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Alessandra Mantovanelli data

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Alessandra Mantovanelli	data

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Abstract

The settling velocity of suspended particulate matter (SPM) is a key parameter controlling deposition processes and its accurate determination has been regarded as a top priority in improving numerical models of cohesive sediment transport. Because SPM occurs predominantly as aggregates of organic and inorganic particles in cohesive coastal systems, an *in situ* quantification of settling velocity is essential. The available techniques to measure the settling velocity of aggregates in the field include: Owen tubes and similar, settling columns equipped with optical sensors, laser systems or video cameras as well as acoustics and holographic systems. None of these techniques is able to directly measure the mass-concentration of SPM or its settling velocity mass distribution *in situ*.

In this work, a new instrument (SEDVEL – Sedimentation Velocity) was developed to directly and automatically measure SPM mass of cohesive sediments *in situ*, from which the mass/concentration distribution of settling velocities can be determined. This instrument consists of an underwater balance (resolution of 0.01 g) placed inside a settling tube, which directly measures the variation in time of the immersed weight of particulate matter (*PM*) as it settles on a plate located at the tube bottom under quiescent conditions. SEDVEL operates underwater and automatically withdraws water samples — deployment periods of a few days. The design of SEDVEL and its components are described as well as the procedure adopted in its calibration and data analysis. Results of the assessment of the instrument performance in the laboratory and in the field are analysed.

SEDVEL presented consistent and reproducible results when tested in the laboratory. It was able to reproduce the initial particles concentrations ranging from 7 to 200 mg l^{-1} ($r^2 = 0.9$, $p < 0.01$) in 13 laboratory experiments. Results also suggested that some particle reflocculation induced by the settling column can take place for concentrations higher than 50 mg l^{-1}. Field trials, carried out in Cleveland Bay at Berth 11 (Townsville Harbour, Australia) and at the Pier (Strand Beach, Townsville, Australia), showed that SEDVEL reproduced the general tendency of the measured SPM concentrations in 42 cycles of measurement ($r^2 = 0.65$, $p < 0.01$).

At the Pier, settling velocities presented a main mode of relatively slow-settling particles/flocs within $0.09 \leq W_s < 0.5$ mm s^{-1}, and usually a second mode of $1.5 \leq W_s < 3.0$ mm s^{-1}. The settling dynamics at this location were mainly determined by erosion and deposition of sediment particles from and to the bottom close to the headland as well as by advection of offshore floc populations during the rising tide. At Berth 11, aggregates were composed mainly of microflocs of low-density and slow settling velocities ($0.09 \leq W_s < 0.12$ mm s^{-1}). The estimated mean density of flocs, 40% smaller than the density of inorganic particles, represented better the settling mode measured at this site.

SEDVEL constituted a novel idea for measuring settling velocities *in situ*, and therefore, a considerable amount of development, prototyping and testing was required. Compared with other automated instruments for measuring settling velocities *in situ*, SEDVEL has a relatively simple working principle, calibration and data analysis procedure. It is also unique in furnishing direct and automated *in situ* measurements of immersed mass and mass-concentration of SPM. The main problems associated with the current SEDVEL version are: zero position drifting among the different cycles of the measurement and from its initial set-up, possible floc break-up due to the pumping system used in the water replacement, errors associated with a non-homogeneous distribution of particles on the balance plate and with the definition of the zero position. A general assessment of SEDVEL potential limitations, and improvements to be achieved in future versions of the instrument, are described.

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